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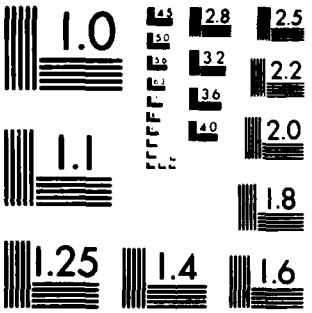

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The view, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

sparisity, optimization, nonlinear equations, inaccurate function values, systolic arrays, numerical linear algebra.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The major thrust of the research accomplished under this grant is toward algorithms for large problems, although there have been other results along the way, like connections between accuracy attainable by Newton-like methods and noise in residual computations. The main thrusts were toward finding a variable-metric technique for large sparse nonlinear optimization problems by the novel approach of defining the sparse derivative matrix approximations in terms of their sparse factorizations which would be updated at each iteration, (CONTINUED)

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cont → and toward designing algorithms that exploit the systolic array architecture in numerical linear algebra.

Variable Metric Secant Updates from Matrix Factorizations

Final Report

J.E. Dennis and Franklin Luk

April 21, 1983

U.S. Army Research Office

DAAG 29-79-C0124

Rice University

TECHNICAL SUMMARY

The major thrust of the research accomplished under this grant is toward algorithms that extend the size of problems we can effectively solve, although there have been other results along the way. Most of this technical material has been previously reported, but there has been substantial progress since the last report and we will concentrate on that here.

This project began with the main goal of finding a variable-metric technique for large sparse nonlinear optimization problems by the novel approach of defining the sparse derivative matrix approximations in terms of their sparse factorizations which would be updated at each iteration. We are preparing a paper dealing with our findings for the Cholesky factorization. Our idea seems to be sound, but more work is needed to make the work practical. On the other hand, the LU form, introduced in the joint paper with Marwil for nonlinear simultaneous equations, is a success. An interesting extension of that work by researchers in Brazil is forthcoming. Most people in optimization have now given up on the more conventional approach to sparse variable-metric methods because of the scale dependence of the sparsity property, so we expect our factor-updating approach to be considered more in the future.

Franklin Luk has been working with Professor Richard Brent of the Australian National University on algorithms for systolic array machines. This collaboration has so far produced four joint papers, copies of which are enclosed. These papers continue work previously described in progress reports on the exploitation of this novel machine architecture in parallel numerical linear algebra computations.

Since the last progress report, John Dennis and Homer Walker have obtained and written up the results on local improvement theorems which are enclosed with this report. It is always difficult to tell how results will be received by the numerical community, but these results seem to be a great help in understanding the effects of modeling and computational errors in determining the attainable accuracy and speed of convergence to a solution of that accuracy for a system of nonlinear equations. The final goals of this research are to furnish a front-end to our research reported in a previous progress report on exploiting 'almost-sparsity' in nonlinear problems, especially discretizations of nonlinear pde's, and more fundamentally, we hope eventually to modify library subroutines like MINPACK to supply the user-supplied function subroutine with an accuracy requirement with each function evaluation request. This has the potential for enormous computational savings in inverse problems where the function evaluation is the result of a numerical simulation, since it would furnish a rational scheme for a less accurate simulation early in the parameter-identification process.

PUBLICATIONS BY J.E.DENNIS

(1) (with R. Schnabel) A new derivation of symmetric positive definite secant updates, Nonlinear Programming III, edited by R. Meyer, S. Robinson, Academic Press (1981), pp. 167-199.

(2) (with H.F. Walker) Convergence Theorems for Quasi-Newton Methods, SIAM J. on Numerical Analysis, 18,(1981), pp.949-987.

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(5) (with H.F. Walker) Inaccuracy in Quasi-Newton Methods: Local Improvement Theorems, Rice MASC TR 83-11, submitted for publication.

(6) Lecture Notes for a Short Course in Unconstrained Optimization, to appear

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(8) (with Phuong Vu) Toward Direct Sparse Updates of Cholesky Factors, in preparation.

PUBLICATIONS BY FRANKLIN LUK

(9) (with R.R.Gerber) A Generalized Broyden's Method for Solving Simultaneous Linear Equations, SIAM J. for Numerical Analysis 18(1981),pp882-890.

(10) (with A.Finn and C.Pottle) Systolic Array Computation of the Singular Value Decomposition, to appear.

(11) Orthogonal Rotation to a Partially Specified Target, to appear.

(12) (with Richard Brent) Computing the Cholesky Factorization Using a Systolic Architecture, to appear.

(13) On the Minres Method of Factor Analysis, submitted for publication.

(14) (with Richard Brent) A Systolic Architecture for the Singular Value Decomposition, submitted for publication.

(15) (with Richard Brent) A Systolic Architecture for Almost Linear-Time Solution of the Symmetric Eigenvalue Problem, submitted for publication.

(16) (with Richard Brent) A Systolic Array for the Linear-Time Solution of Toeplitz Systems of Equations, submitted for publication.

PARTICIPATING SCIENTIFIC PERSONNEL:

J.E. Dennis, Franklin Luk, Richard Tapia, Daniel Woods.


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